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TOPICAL OUTLINE

WITH

Definitions of the

ELEMENTS OF

NATURAL

PHILOSOPHY.

ARRANGED BY

CLIFTON SCOTT, M. D.

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## PREFACE.

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THE reception of the Author's Outlines of Physiology and Botany by his pupils led to the preparation of an outline similar to this. During its use the demands for it in a printed form have decided the Author to publish it. It has been carefully revised and brought up to the present status of physical science.

It is not arranged with regard to any text book, as students who will use it will be far enough advanced to study a subject rather than a book.

The loss of time incident to the deduction of good definitions from the wordy, illustrated discussions of our authors has led to the introduction of brief definitions.

Discussions of theory and descriptions of machines have been omitted, as there is no thought of making this a text book. The intent of the author was to make this a source of topics for the comparison of authors.

CLIFTON SCOTT, M. D.



## 1<sup>1</sup> NATURAL PHILOSOPHY.

### 1<sup>2</sup> General Definitions.

1<sup>3</sup> Science:—Knowledge so classified as to show the relations between object and phenomena.

2<sup>3</sup> Phenomena:—Any occurrence of nature having a cause and effect.

3<sup>3</sup> Law:—A statement of what has occurred under all observations of the same conditions.

4<sup>3</sup> Cause and Effect:—(a) That which produces a result.

(b) The result of a cause.

5<sup>3</sup> Chance:—Occurrences for which the causes are obscure.

6<sup>3</sup> Hypothesis:—Suppositions made to explain phenomena for which the cause cannot be proved.

7<sup>3</sup> Theory:—A supposition which is sustained by most known facts.

8<sup>3</sup> Time:—Duration, as shown by uniform recurrences of the similar events.

9<sup>3</sup> Space:—The idea of volume without regard to what may occupy it.

### 2<sup>2</sup> Parts.

#### 1<sup>3</sup> Matter.

1<sup>4</sup> Definition:—Anything which occupies space.

2<sup>4</sup> Divisions.

- 1<sup>5</sup> Atom:—Smallest particle of matter that can exist in combination.
- 2<sup>5</sup> Molecule:—The smallest particle of a substance which can exist alone and exhibit the properties of that substance.
- 3<sup>5</sup> Mass.
  - 1<sup>6</sup> Definition:—An aggregation of molecules, a definite quantity of matter.
  - 2<sup>6</sup> Measurement of.
- 3<sup>4</sup> Classes.
  - 1<sup>5</sup> Mixtures:—Quantities of matter composed of unlike molecules.
  - 2<sup>5</sup> Substances:—Matter composed of like molecules.
    - 1<sup>6</sup> Simple:—Like molecules, composed of like atoms.
    - 2<sup>6</sup> Compound:—Like molecules, composed of unlike atoms.
- 4<sup>4</sup> Properties.
  - 1<sup>5</sup> Chemical:—Those which cannot be exhibited without a change in the composition of the molecule.
  - 2<sup>5</sup> Physical:—Those which can be exhibited without changing the composition of the molecule.
    - 1<sup>6</sup> General:—Properties possessed by all matter.
    - 1<sup>7</sup> Mass.

- 2<sup>7</sup> Weight:—Measure of the force of gravity.
- 3<sup>7</sup> Extension:—The property of occupying space.
- 4<sup>7</sup> Indestructibility:—The property which makes annihilation of matter impossible.
- 5<sup>7</sup> Impenetrability:—The property which prevents two bodies from occupying the same space at the same time.
- 6<sup>7</sup> Inertia:—A name for the fact that matter has no power to change its own condition of rest or motion.
- 2<sup>6</sup> Specific:—Properties not possessed by all matter.
- 1<sup>7</sup> Of Solids.
  - 1<sup>8</sup> Hardness:—The degree of resistance a body offers to an effort to force another body between its particles.
  - 2<sup>8</sup> Tenacity:—A measure of the force required to pull the molecules of a substance apart.
  - 3<sup>8</sup> Ductility:—The property which permits some substances to be drawn into wire.
  - 4<sup>8</sup> Malleability:—The property of some substances which enables them to be beaten or rolled into thin sheets.
  - 5<sup>8</sup> Viscosity:—That condition of body

which allows slow change of form under force but fractures under sudden impulses.

2<sup>7</sup> Of Liquids and Gases.

1<sup>8</sup> Compressibility:—

2<sup>8</sup> Diffusion:—The property which causes liquids in contact to mix although of different density.

1<sup>9</sup> Examples.

1<sup>10</sup> Crystalloids:—Crystalline substances in solution.

2<sup>10</sup> Colloids:—Substances which are gelatinous when moist.

2<sup>9</sup> Rates for Gases and Liquids.

5<sup>4</sup> Constitution.

1<sup>5</sup> Divisibility.

2<sup>5</sup> Atomic Theory.

3<sup>5</sup> Chemical Affinity:—Tendency to acceleration among atoms.

4<sup>5</sup> Molecular Composition.

5<sup>5</sup> Porosity.

6<sup>5</sup> Intermolecular Spaces.

7<sup>5</sup> Expansibility.

8<sup>5</sup> Compressibility.

6<sup>4</sup> Conditions of Matter.

1<sup>5</sup> Solids.

1<sup>6</sup> Definition:—Bodies which retain their form unless acted upon by energy.

2<sup>6</sup> Changes:—How produced?

2<sup>5</sup> Fluids.

1<sup>6</sup> Definition:—Matter which changes form unless retained in a vessel.

2<sup>6</sup> Aeriform.

1<sup>7</sup> Definition:—Matter in which the molecules tend to separate indefinitely.

2<sup>7</sup> Kinds.

1<sup>8</sup> Gases:—Those which are aeriform at ordinary temperatures.

1<sup>9</sup> Examples.

2<sup>9</sup> Changes:—How produced.?

2<sup>8</sup> Vapors:—Those which are kept in aeriform state by application of heat.

1<sup>9</sup> Example.

2<sup>9</sup> Changes.

3<sup>6</sup> Liquids:—Those fluids in which molecules cling together with slight force.

2<sup>3</sup> Kinematics.

1<sup>4</sup> Definition:—That branch of physics which treats of motion.

2<sup>4</sup> Terms.

1<sup>5</sup> Direction:—The angles a line makes with other lines to which it is referred.

2<sup>5</sup> Position:—Distance and direction from some point used for reference.

3<sup>5</sup> Rest:—That condition of a body when fixed with regard to a reference point.

- 4<sup>5</sup> Motion:—Continuous change of position,  
always relative.
- 1<sup>6</sup> Direction of.
  - 1<sup>7</sup> How Determined?
  - 2<sup>7</sup> Rectilinear:—Result of one force.
  - 3<sup>7</sup> Circular:—Result of two forces.
- 2<sup>6</sup> Uniform.
- 3<sup>6</sup> Constant.
- 4<sup>6</sup> Velocity:—Speed or rate of motion.
  - 1<sup>7</sup> Constant.
  - 2<sup>7</sup> Average.
  - 3<sup>7</sup> Acceleration:—A continual change of  
velocity.
    - 1<sup>8</sup> Uniform.
    - 2<sup>8</sup> Variable.
    - 3<sup>8</sup> Uniform and Accelerated Motion  
Combined.
- 5<sup>6</sup> Composition.
  - 1<sup>7</sup> Illustrations.
  - 2<sup>7</sup> Resultants.
    - 1<sup>8</sup> Of Two Motions.
    - 2<sup>8</sup> Of Several Motions.
  - 3<sup>7</sup> Parallelogram of Motion.
  - 4<sup>7</sup> Diagrams for Velocity.
    - 1<sup>8</sup> For Uniform.
    - 2<sup>8</sup> For Acceleration.
- 6<sup>6</sup> Resolutions.
  - 1<sup>7</sup> Of Two Motions.
  - 2<sup>7</sup> Of Several Motions.

7<sup>6</sup> Laws.

1<sup>7</sup> First:—Motion is in the direction of the force producing it and proportional to it.

2<sup>7</sup> Second:—A force produces the same effect whether acting alone or in combination with other forces.

3<sup>7</sup> Third:—Action and reaction are equal and in opposite directions.

3<sup>3</sup> Energy.

1<sup>4</sup> Definition:—Capacity for doing work.

2<sup>4</sup> Units.

1<sup>5</sup> Foot-pound:—The energy required to move one pound one foot against the force of gravity.

2<sup>5</sup> Erg:—The energy required to move one gramme one centimeter against the force of one dyne.

3<sup>4</sup> Nature of.

4<sup>4</sup> Motion Necessary to.

5<sup>4</sup> Effect of Velocity.

6<sup>4</sup> Effect of Mass.

7<sup>4</sup> Indestructibility.

8<sup>4</sup> Conservation.

9<sup>4</sup> Contrast Momentum and Energy.

10<sup>4</sup> Kinds.

1<sup>5</sup> Potential.

1<sup>6</sup> Definition:—Ability to acquire energy.

2<sup>5</sup> Examples.

2<sup>5</sup> Kinetic.

1<sup>6</sup> Definition:—The effect of visible onward motion.

2<sup>6</sup> Examples.

11<sup>4</sup> Products of.1<sup>5</sup> Force.

1<sup>6</sup> Definition:—Anything which tends to produce acceleration in matter.

2<sup>6</sup> How Recognized?

3<sup>6</sup> Examples of.

1<sup>7</sup> Elasticity.

1<sup>8</sup> Definition:—The tendency of matter to resume its former size and shape after being distorted by an external force.

2<sup>8</sup> Forms.

1<sup>9</sup> Extension.

2<sup>9</sup> Flexion.

3<sup>9</sup> Compression.

4<sup>9</sup> Torsion.

5<sup>9</sup> All Forms Alike.

2<sup>7</sup> Attraction and Repulsion.

1<sup>8</sup> Electrical.

2<sup>8</sup> Magnetic.

3<sup>8</sup> Gravitation.

1<sup>9</sup> Definition:—The tendency of every particle of matter to approach every other particle.

2<sup>9</sup> Direction of.

3<sup>o</sup> Laws.

1<sup>10</sup> First:—Varies directly as the product of the masses.

2<sup>10</sup> Second:—Varies inversely as the square of the distance between the centers of the attracting bodies.

4<sup>o</sup> Facts Concerning.

1<sup>10</sup> Instantaneous Action.

2<sup>10</sup> Interposition of Substances.

3<sup>10</sup> Kind of Matter Acted Upon.

5<sup>o</sup> Terms referring to.

1<sup>10</sup> Gravity:—The gravitation of the earth upon bodies near it.

2<sup>10</sup> Weight:—Measure of the force of gravity upon a body.

1<sup>11</sup> At the Earth's Surface.

1<sup>12</sup> In Different Latitudes.

2<sup>12</sup> On Mountains and in Valleys.

2<sup>11</sup> Above the Earth's Surface.

3<sup>11</sup> Below the Earth's Surface.

3<sup>10</sup> Center of Gravity.

1<sup>11</sup> Definition.

2<sup>11</sup> Plumb Line.

3<sup>11</sup> Position of.

1<sup>12</sup> How Found?

2<sup>12</sup> Things Effected by.

- 1<sup>13</sup> Equilibrium:—Conditions of a body, when left to itself, it will remain at rest and exist only when the center of gravity is vertical above or below the point of support.
- 1<sup>14</sup> Stable:—The condition of body when any effort to overturn it must first elevate its center of gravity.
- 2<sup>14</sup> Unstable:—Condition of a body in which any effort to overturn it will first lower its center of gravity.
- 3<sup>14</sup> Neutral:—Condition of a body in which efforts to overturn will not change the relation of the center of gravity to the point of support.
- 2<sup>13</sup> Stability.
  - 1<sup>14</sup> Definition:—A measure of the work required to overturn a body.
  - 2<sup>14</sup> Terms.
    - 1<sup>15</sup> Base.

- 2<sup>15</sup> Line of Direction.
- 3<sup>14</sup> Depends upon what?
- 6<sup>9</sup> Accelerations by.
  - 1<sup>10</sup> Planets.
  - 2<sup>10</sup> Projectiles:—Bodies put in motion by a single, sudden impulse or force.
  - 1<sup>11</sup> Range:—A parabola, due to the force of gravity acting obliquely to the direction of the initial force.
  - 2<sup>11</sup> Time.
  - 3<sup>11</sup> Range.
  - 3<sup>10</sup> Falling Bodies.
    - 1<sup>11</sup> Laws.
      - 1<sup>12</sup> Time for Different Substances.
      - 2<sup>12</sup> Velocity at end of any Second.
      - 3<sup>12</sup> Distance in any Given Second.
      - 4<sup>12</sup> Distance in any Number of Seconds.
    - 2<sup>11</sup> Examples.
  - 4<sup>10</sup> Pendulum.
    - 1<sup>11</sup> Definition.
    - 2<sup>11</sup> Terms.
      - 1<sup>12</sup> Arc:—The part of a circle

described by a pendulum in vibrating.

- 2<sup>12</sup> Vibration:— One movement of a pendulum over its arc.
- 3<sup>12</sup> Amplitude:— The angular distance measured by half the arc of a pendulum.
- 4<sup>12</sup> Time:— Period required for one vibration.
- 5<sup>12</sup> Bob:—Weight at bottom of rod in compound pendulum.
- 6<sup>12</sup> Center of oscillation:—Point in pendulum which is not accelerated by the other parts.
- 7<sup>12</sup> Point of suspension:—Point about which the pendulum vibrates. It is interchangeable with the center of oscillation.
- 3<sup>11</sup> Kinds.
  - 1<sup>12</sup> Simple:—A single material particle supported by a line without weight, capable of vibrating about a fixed point.
  - 2<sup>12</sup> Compound:—A weight suspended so as to vibrate about a fixed point.

- 3<sup>12</sup> Cycloidal : — A pendulum vibrating between the adjacent halves of two cycloidal curves and adapting itself to them.
- 4<sup>12</sup> Seconds : — One vibrating seconds.

4<sup>11</sup> Laws.

- 1<sup>12</sup> First:—Time of vibration is independent of mass or material
- 2<sup>12</sup> Second: — Times of vibration for the same pendulum are isochronous if the amplitude be small.
- 3<sup>12</sup> Third:—The times of vibration in different pendulums are proportional to the square roots of their lengths.
- 4<sup>12</sup> Fourth:—The times of vibration of the same pendulum are inversely as the square roots of gravity, hence will not vary with latitude and altitude.

5<sup>11</sup> Applications.

- 1<sup>12</sup> Time Keeper.
- 1<sup>13</sup> Clock Work.

- 2<sup>13</sup> Variations.
  - 1<sup>14</sup> By Heat.
  - 2<sup>14</sup> By Change of Location.
- 3<sup>13</sup> Regulation of.
  - 1<sup>14</sup> By Raising and Lowering Bob.
  - 2<sup>14</sup> By Compensation.
    - 1<sup>15</sup> Gridiron.
    - 2<sup>15</sup> Mercurial.
  - 2<sup>12</sup> Measure Elevations.
  - 3<sup>12</sup> Prove Rotation of the Earth.
- 4<sup>8</sup> Cohesion and Adhesion. (Molecular Forces.)
  - 1<sup>9</sup> Definition:—(a) Cohesion the force which holds together like molecules. (b) Adhesion the force which holds together unlike molecules.
  - 2<sup>9</sup> Illustrations.
  - 3<sup>9</sup> Modifications.
    - 1<sup>10</sup> Tempering.
      - 1<sup>11</sup> Definition:—Securing a certain degree of hardness.
    - 2<sup>11</sup> Description of Process.
      - 1<sup>12</sup> In Steel.
      - 2<sup>12</sup> In Copper.
  - 2<sup>10</sup> Surface Tension.
    - 1<sup>11</sup> Examples.
      - 1<sup>12</sup> In Liquids.

- 2<sup>12</sup> Prince Rupert's Drops.
- 2<sup>11</sup> Cause.
- 3<sup>10</sup> Annealing :—Securing uniform tension.
- 1<sup>11</sup> Definition.
- 2<sup>11</sup> Process.
- 1<sup>12</sup> In Wire.
- 2<sup>12</sup> In Glass.
- 3<sup>11</sup> Why Necessary.
- 4<sup>9</sup> Manifestations.
- 1<sup>10</sup> Crystallization.
- 1<sup>11</sup> Definition :—Arrangement of molecules so as to produce solids of definite form.
- 2<sup>10</sup> Solutions.
- 1<sup>11</sup> Definition :—The permanent suspension of substances in liquids so as to render the particles invisible even with the microscope.
- 2<sup>11</sup> Kinds.
- 1<sup>12</sup> Saturated :—One where no more of the substance can be suspended in a given volume of the liquid.
- 2<sup>12</sup> Unsaturated :—One where the liquid has power to suspend more of the substance in a given volume.

3<sup>10</sup> Capillarity.

1<sup>11</sup> Definition.—A change of level in the surfaces of liquids where solids are partly immersed in them.

2<sup>11</sup> Law:—In tubes, the height for the same liquid is inversely as the diameter of the tube

3<sup>11</sup> Kinds.

1<sup>12</sup> Elevation.

2<sup>12</sup> Depression.

4<sup>11</sup> Illustrations.

4<sup>10</sup> Osmose.

1<sup>11</sup> Definition:—Diffusion through porous membranes.

2<sup>11</sup> Of Gases.

3<sup>11</sup> Of Liquids.

4<sup>6</sup> Measurements.1<sup>7</sup> Apparatus.

1<sup>8</sup> Spring Balance.

2<sup>8</sup> Equal Arm Balance.

3<sup>8</sup> For Acceleration.

1<sup>9</sup> Same Force on Different Masses.

2<sup>9</sup> Same Mass and Different Forces.

2<sup>7</sup> Standards.

1<sup>8</sup> Length.

1<sup>9</sup> English.

2<sup>9</sup> French.

2<sup>8</sup> Mass.

- 1<sup>o</sup> English.
- 2<sup>o</sup> French.
- 3<sup>s</sup> Time.
- 3<sup>7</sup> Units.
  - 1<sup>s</sup> Scientific.
    - 1<sup>o</sup> Length—Meter.
    - 2<sup>o</sup> Mass—Gramme.
  - 2<sup>s</sup> British Engineering.
    - 1<sup>o</sup> Length—Foot.
    - 2<sup>o</sup> Mass—Pound.
  - 3<sup>s</sup> Of Force.
    - 1<sup>o</sup> Foot-Pound-Second (Gravity Unit).
    - 2<sup>o</sup> Centimeter - Gramme - Second (Dyne, C. G. S.).
- 4<sup>7</sup> Momentum :— Product of mass and velocity.
- 5<sup>7</sup> Impulse :— Product of force into the time of its action.
- 6<sup>7</sup> Time Required to Set Matter in Motion.
- 2<sup>5</sup> Work.
  - 1<sup>6</sup> Definition:— A name for the process of the transfer or transformation of energy.
  - 2<sup>6</sup> Units:—Same as energy.
  - 3<sup>6</sup> Power.
    - 1<sup>7</sup> Definition:—Rate of work.
    - 2<sup>7</sup> Units.
      - 1<sup>8</sup> Horse-power:—The rate of 550 foot-pounds per second.

- 2<sup>8</sup> Scientific Unit:—13,560,000 ergs.
- 4<sup>5</sup> Measurement of.
  - 1<sup>7</sup> Against or by a Constant Force.
  - 2<sup>7</sup> Independent of Time.
- 12<sup>4</sup> Dynamics:—Action of force and energy.
  - 1<sup>5</sup> Composition of Forces.
    - 1<sup>6</sup> Representation:—Same as velocities and motions.
      - 1<sup>7</sup> By Parallelogram.
      - 2<sup>7</sup> By Polygon.
    - 2<sup>6</sup> Resultant:—The single force equivalent to several combined forces.
      - 1<sup>7</sup> For Parallel Forces.
        - 1<sup>8</sup> In Same Direction.
        - 2<sup>8</sup> In Opposite Direction.
      - 2<sup>7</sup> For Oblique Forces.
    - 3<sup>6</sup> Equilibrium of Forces.
  - 2<sup>5</sup> Resolution of Forces.
    - 1<sup>6</sup> Into Parallel Forces.
    - 2<sup>6</sup> Into Oblique Forces.
      - 1<sup>7</sup> By Parallelograms.
      - 2<sup>7</sup> Examples:—Sailing a ship.
  - 3<sup>5</sup> Arm of a Force.—Radius of a circle in which a force rotates.
  - 4<sup>6</sup> Moment of a Force—Product of force into its arm.
    - 1<sup>6</sup> Kinds.
      - 1<sup>7</sup> Right-Handed:—When producing rota-

tion in the direction of that of the clock.

2<sup>7</sup> Left-Handed:--Rotating opposite to right-handed.

2<sup>6</sup> Equilibrium of:--When left-handed and right-handed moments are equal.

5<sup>5</sup> Couples:--Equal and opposite parallel forces.

6<sup>5</sup> Central Forces.

1<sup>6</sup> Kinds.

1<sup>7</sup> Centrifugal:--Tendency of revolving bodies to move in a straight line, hence to move farther from a center.

2<sup>7</sup> Centripetal:--Force required to keep a revolving body in its circular path.

2<sup>6</sup> Laws.

1<sup>7</sup> First:--Central force is proportional to the square of the number of turns per unit of time.

2<sup>7</sup> Second:--The central force is directly proportional to the radius of the circle.

3<sup>7</sup> Third:--The central force is proportional to the mass.

13<sup>4</sup> Transformations of Energy.

1<sup>5</sup> By Friction.

1<sup>6</sup> Definition of Friction:--The resistance

one body offers to the movement of another over its surface.

2<sup>6</sup> Cause:—The unevenness of surfaces.

3<sup>6</sup> Laws.

1<sup>7</sup> First:—Proportional to the pressure with which the surfaces are held in contact.

2<sup>7</sup> Second:—The friction is independent of the area of the rubbing surfaces.

3<sup>7</sup> Third:—Depends upon the nature of the rubbing surfaces.

4<sup>6</sup> Coefficient of Friction.

5<sup>6</sup> Friction of Repose.

6<sup>6</sup> Friction of Gases and Liquids.

7<sup>6</sup> How Diminished:—By lubricants, by polishing surfaces, by placing unlike substances in contact, etc.

8<sup>6</sup> How Increased:—By making surfaces dry, rough and similar.

9<sup>6</sup> When Valuable.

10<sup>6</sup> When Objectionable.

2<sup>5</sup> In Mechanics.

1<sup>6</sup> Definition:—Mechanics is the science of machines and the art of their construction.

2<sup>6</sup> Mechanics.

1<sup>7</sup> Definition:—Any device for transmitting or transforming energy for the purpose of doing a desired work.

2<sup>7</sup> Uses.

3<sup>7</sup> Kinds.

1<sup>8</sup> Lever.

1<sup>9</sup> Definition:—A rigid bar turning freely about a fixed point called a fulcrum.

2<sup>9</sup> Classes.

1<sup>10</sup> First : — Fulcrum between the two forces, load and power.

2<sup>10</sup> Second:—Load between fulcrum and power.

3<sup>10</sup> Third:—Power between the fulcrum and the load.

3<sup>9</sup> Law of Equilibrium:—The moment of the load must be equal and opposite to the moment of the power.

4<sup>9</sup> Compound.

1<sup>10</sup> Example.

2<sup>10</sup> Law of Equilibrium.

5<sup>9</sup> Bent Levers and Oblique Forces.

6<sup>9</sup> Examples.

7<sup>9</sup> Actual.

8<sup>9</sup> Advantage of.

2<sup>8</sup> Wheel and Axle.

1<sup>9</sup> Description.

2<sup>9</sup> Law of Equilibrium : — Same as lever.

3<sup>9</sup> Wheel Work.

3<sup>s</sup> Inclined Plane.

1<sup>o</sup> Definition: — Any flat surface making an oblique angle with the horizon.

2<sup>o</sup> Law of Equilibrium.

1<sup>10</sup> Power Parallel to Plane.

2<sup>10</sup> Power Parallel to Base.

3<sup>o</sup> Force Necessary to Produce.

4<sup>o</sup> Angle of Repose.

4<sup>s</sup> Wedge.

1<sup>o</sup> Definition: — Two inclined planes their bases together.

2<sup>o</sup> Law of Equilibrium: — Product of the power into the length of the common base of the two inclined planes equal to the product of the load with the thickness of the wedge.

3<sup>o</sup> Uses.

4<sup>o</sup> Examples.

5<sup>s</sup> Screw.

1<sup>o</sup> Definition:—A spiral inclined plane around a cylinder or body.

2<sup>o</sup> Terms.

1<sup>10</sup> Nut.

2<sup>10</sup> Body.

3<sup>10</sup> Threads.

4<sup>10</sup> Pitch.

3<sup>o</sup> Law of Equilibrium:—The product

of the power into the circumference of the circle it describes equals the product of the load into the vertical distance between two successive threads.

4<sup>9</sup> Uses.

6<sup>8</sup> Pulleys.

1<sup>9</sup> Definition:—A grooved wheel over which is passed a cord.

2<sup>9</sup> Law of Equilibrium.

1<sup>10</sup> For Single Fixed Pulley:—Power equals load.

2<sup>10</sup> For a System with Continuous Rope:—Load equals the product of the power into the number of branches of rope supporting the load.

3<sup>10</sup> For System with Several Separate Ropes.

3<sup>9</sup> Uses.

7<sup>8</sup> Knee or Toggle Joint.

4<sup>3</sup> Hydrostatics.

1<sup>4</sup> Definition:—That branch of physics which treats of liquids at rest.

2<sup>4</sup> Transmission of Pressure by Liquids.

1<sup>5</sup> Law:—Pressure upon any portion of the surface of a liquid confined in a vessel will be transmitted equally in all directions, that is the same pressure will be

exerted upon all equal areas of the containing vessel.

2<sup>5</sup> Illustrations.

1<sup>6</sup> Hydrostatic Press.

2<sup>6</sup> Hydrostatic Bellows.

3<sup>6</sup> Bursting Barrel.

3<sup>4</sup> Pressure of Liquids.

1<sup>5</sup> Cause:—Weight of Liquids.

2<sup>5</sup> Intensity:—Depends solely upon depth.

3<sup>5</sup> At any Point in the Liquid:—Equal in all directions.

4<sup>5</sup> Determination on Surfaces.

1<sup>6</sup> Law:—Multiply area pressed, by depth of its center below the surface of the liquid and that by the weight of a unit volume of water.

2<sup>6</sup> Applications of the Law.

1<sup>7</sup> Downward.

2<sup>7</sup> Upward.

3<sup>7</sup> Laterally.

5<sup>5</sup> Level Surfaces.

1<sup>6</sup> Definition:—A surface every point in which is equally distant from the earth's center of gravity.

2<sup>6</sup> In Communicating Vessels.

3<sup>6</sup> Spirit Level.

4<sup>6</sup> In Water Works.

5<sup>6</sup> Deviation from a Line Straight or Tangent to the Surface:—The deviation of

a unit's distance multiplied by the square of the distance.

6<sup>s</sup> In Jets:—Counteracted by friction of nozzle, air, and falling drops.

7<sup>s</sup> Buoyancy of Liquids.

1<sup>6</sup> Definition:—The supporting power of liquids upon bodies submerged in them or floating upon them.

2<sup>6</sup> Principle of Archimedes:—A body in a liquid loses a weight equal to the weight of the volume of liquid displaced.

3<sup>6</sup> Floating bodies:—Those which weigh less than an equal volume of the supporting liquid.

8<sup>6</sup> Specific Gravity.

1<sup>7</sup> Definition:—The ratio of the mass of any volume of the given substance to the mass of an equal volume of pure water at a standard temperature.

2<sup>7</sup> Standard:—Generally water.

3<sup>7</sup> How Determined.

1<sup>8</sup> In Solids Heavier than Water:—  
Divide the weight in air by the loss of weight in water.

2<sup>8</sup> In Solids Lighter than Water:—  
Attach a sinker to the light body, divide the weight of the light body

by the difference between the loss of weight of the heavy body in water and the loss of the combined masses in water.

3<sup>s</sup> In Liquids.

1<sup>o</sup> By Specific Gravity Flasks.

2<sup>o</sup> By Hydrometers.

1<sup>10</sup> Description.

2<sup>10</sup> Graduations.

4<sup>7</sup> Applications:—To find weights, adulterations, etc.

5<sup>s</sup> Hydraulics.

1<sup>4</sup> Definition:—That branch of physics which treats of liquids in motion.

2<sup>4</sup> Standard:—Water.

3<sup>4</sup> Flow of Liquids.

1<sup>5</sup> From Orifices.

1<sup>6</sup> Law of Velocity:—Same as a freely falling body would acquire in falling from the surface of the liquid to the center of the orifice.

2<sup>6</sup> Law of Quantity:—Multiply the velocity of the stream by the area of the orifice and that product by the time.

3<sup>6</sup> Why is Quantity Less than Theory:—Because of counter currents inside orifice and of the friction of the orifice.

4<sup>6</sup> Vena Contracta:—The constricted portion of the stream outside the orifice.

- 5<sup>6</sup> Path of stream:—Same as projectile.
- 6<sup>6</sup> Range of Stream:—Openings equally distant from top and bottom of containing vessel will give equal range, one at center will be greatest.
- 7<sup>6</sup> Effect of Short Tubes:—Tubes greater in diameter than the Vena Contracta and extending slightly beyond it will increase the quantity by the adhesion of liquid for the pipe preventing the Vena Contracta becoming as small as it otherwise would.
- 8<sup>6</sup> Effect of Long Tubes:—The flow will be the same in all parts but the pressure will diminish, and hence the amount discharged in proportion to the friction; this friction increases with length, roughness, turns, diminution of diameter, etc., of pipe. The same is true of rivers.
- 2<sup>5</sup> In the Soil.
  - 1<sup>6</sup> Wells.
  - 2<sup>6</sup> Springs.
  - 3<sup>6</sup> Artesian Wells.
- 3<sup>5</sup> Water Wheels:—Devices to utilize the force of gravity in flowing and falling water.
  - 1<sup>6</sup> Over Shot.
  - 2<sup>6</sup> Under Shot.
  - 3<sup>6</sup> Breast.

4<sup>6</sup> Turbine.4<sup>4</sup> Waves.

1<sup>5</sup> Cause:—Some force, as the wind acting unequally upon the surface of liquids.

2<sup>5</sup> Kinds.

1<sup>6</sup> Oscillation:—Where the particles have a vibratory motion which alternately lengthens and shortens the vertical columns of the liquids.

2<sup>6</sup> Translation:—These are solitary and the particles are picked up, transferred and deposited in a new place.

3<sup>5</sup> Terms.

1<sup>6</sup> Phase:—Any particular part of the curve.

2<sup>6</sup> Crest:—The elevated part.

3<sup>6</sup> Trough:—The depressed part.

4<sup>6</sup> Length:—Horizontal distance between two successive like phases.

4<sup>5</sup> Interference.5<sup>5</sup> Effects.6<sup>5</sup> Height.6<sup>3</sup> Pneumatics.

1<sup>4</sup> Definition:—That branch of physics which treats of gases.

2<sup>4</sup> Type:—Air.

1<sup>5</sup> Properties.

1<sup>6</sup> Weight.

2<sup>5</sup> Elasticity.

3<sup>6</sup> Expansibility:—A quantity of gas, no mat

ter how small, will fill a space no matter how great.

4<sup>6</sup> Compressibility:—Volume varies as the pressure, (Boyle's Law).

2<sup>5</sup> Pressure.

1<sup>6</sup> In What Directions.

2<sup>6</sup> How proved?

1<sup>7</sup> By Hand Glass.

2<sup>7</sup> By Madgeburg Hemispheres.

3<sup>6</sup> Amount of Pressure.

1<sup>7</sup> Per Square Inch:—An average of 14.7 pounds in this latitude at the sea level, usually called 15 pounds.

2<sup>7</sup> Torricellian Experiment.

3<sup>7</sup> Pascal's Experiments.

4<sup>6</sup> Applications of.

1<sup>7</sup> Barometer.

1<sup>8</sup> Kinds.

1<sup>9</sup> Siphon:—A "U" tube with unequal arms and the short arm closed and a vacuum in the short arm above the contained liquid.

2<sup>9</sup> Cistern:—A straight tube with upper end closed and a vacuum above the contained liquid, the open end being below the surface of a liquid in a reservoir having an adjustable bottom that readings may be made of

begin at the same point.

3<sup>o</sup> Mercurial.

4<sup>o</sup> Water.

5<sup>o</sup> Aneroid.

2<sup>8</sup> Utility.

1<sup>o</sup> Measure Altitudes.

2<sup>o</sup> Predict Storms.

2<sup>7</sup> Pumps.

1<sup>8</sup> Air Pump.

2<sup>8</sup> Condenser.

3<sup>8</sup> Lifting Pump.

1<sup>o</sup> Construction.

2<sup>o</sup> Limit of Height.

4<sup>8</sup> Forcing.

1<sup>o</sup> Construction.

2<sup>o</sup> Air Dome.

5<sup>8</sup> Rotary.

3<sup>7</sup> Siphon.

1<sup>8</sup> Construction.

2<sup>8</sup> Source of Energy.

3<sup>4</sup> Atmosphere.

1<sup>5</sup> Definition:—Gaseous layer around the earth

2<sup>5</sup> Depth.

3<sup>5</sup> Buoyancy.

1<sup>6</sup> Balloons.

2<sup>6</sup> Weighing in and out of a Vacuum.

3<sup>6</sup> Draft in Chimneys.

7<sup>8</sup> Forms of Energy.

1<sup>4</sup> Heat.

1<sup>5</sup> Definition:—Heat is a form of energy due to irregular molecular vibration and produces in animals the sensation of warmth and cold.

2<sup>5</sup> Effects of.

1<sup>6</sup> Varies Temperature and Quantity of Heat

1<sup>7</sup> Definition of Temperature:—A measure of the ability of a body to yield heat to other bodies. It is no measure of the quantity of heat the body may yield.

2<sup>7</sup> Measurement of Temperature.

1<sup>8</sup> Thermometers:—Instruments for the measure of temperature.

1<sup>9</sup> Kinds.

1<sup>10</sup> Mercurial.

2<sup>10</sup> Alcoholic.

2<sup>9</sup> Scales.

1<sup>10</sup> Fahrenheit.

2<sup>10</sup> Centigrade.

3<sup>10</sup> Reaumer.

4<sup>10</sup> Maximum and Minimum.

3<sup>9</sup> Construction.

2<sup>8</sup> Temperature Compensation.

3<sup>7</sup> Measurements of Quantity.

1<sup>8</sup> Thermal Units:—The quantity of heat required to raise a unit mass of water through one degree of temperature.

## TOPICAL OUTLINE OF

- 1<sup>o</sup> To Raise a Kilogram of Water through 1<sup>o</sup> C. (A Calorie).
- 2<sup>o</sup> To Raise a Gram of Water through 1<sup>o</sup> C. (A Lesser Calorie).
- 3<sup>o</sup> To Raise a Pound of Water through 1<sup>o</sup> C.
- 4<sup>o</sup> To Raise a Pound of Water through 1<sup>o</sup> F.
- 5<sup>o</sup> How Found.
  - 1<sup>10</sup> By Mixtures.
  - 2<sup>10</sup> By Time of Heat Application.
- 2<sup>s</sup> Specific Heat.
  - 1<sup>o</sup> Definition:—The ratio of the quantity of heat required to warm a given mass of any substance one degree to the quantity required to warm an equal mass of water one degree.
  - 2<sup>o</sup> How Measured.
    - 1<sup>10</sup> By Mixtures.
    - 2<sup>10</sup> By Melting in Calorimeter.
- 3<sup>s</sup> Latent Heat.
  - 1<sup>o</sup> Definition:—The heat which changes molecular cohesion and is lost to the thermometer during the fusion or vaporization of a substance.
  - 2<sup>o</sup> Of Water:—80<sup>o</sup> C. or 144<sup>o</sup> F.
  - 3<sup>o</sup> Of Steam:—537<sup>o</sup> C. or 966.6<sup>o</sup> F.

2<sup>6</sup> Produces Expansion.1<sup>7</sup> In Solids.2<sup>7</sup> In Liquids and Gases.3<sup>7</sup> Coefficient of Expansion.1<sup>8</sup> Linear.2<sup>8</sup> Cubical.4<sup>7</sup> Compensation for Temperature.5<sup>7</sup> Exceptions.3<sup>6</sup> Fusion.1<sup>7</sup> Definition:—The conversion of solids into liquids by heat.2<sup>7</sup> Laws.1<sup>8</sup> First:—Pressure being constant the temperature at which any substance fuses is constant. No two substances fusing at the same temperature.2<sup>8</sup> Second:—During fusion temperature remains constant.3<sup>8</sup> Third:—Varying pressure varies fusing point.4<sup>8</sup> Fourth:—Under constant pressure a given mass of any substance always requires the same definite quantity of heat to fuse it.3<sup>7</sup> Alloys.1<sup>8</sup> Definition:—A mixture obtained by fusing different metals together.2<sup>8</sup> Why Useful.

4<sup>6</sup> Vaporization.

1<sup>7</sup> Definition:—Passage of substances from solid or liquid to gaseous or vapor state.

2<sup>7</sup> Evaporation.

1<sup>8</sup> Definition:—Slow surface vaporization.

2<sup>8</sup> Variation of Amount.

1<sup>9</sup> By Temperature.

2<sup>9</sup> Amount of Surface.

3<sup>9</sup> By Renewal of Air.

4<sup>9</sup> By Dryness of Air.

3<sup>7</sup> Ebullition.

1<sup>8</sup> Definition:—Rapid production of vapor within and at the bottom of liquids and their consequent agitation by the escaping bubbles. (boiling.)

2<sup>8</sup> Boiling Point.

1<sup>9</sup> Definition:—The temperature at which ebullition takes place, under ordinary atmospheric pressure.

2<sup>9</sup> Variation of.

1<sup>10</sup> By Pressure.

2<sup>10</sup> By Nature of the Vessel.

3<sup>8</sup> Laws of Boiling.

1<sup>9</sup> First.—Under constant pressure, every substance has a definite

pressure at which it boils.

2<sup>9</sup> Second:—This temperature remains constant during boiling.

4<sup>8</sup> Distillation.

1<sup>9</sup> Definition:—The process of separating liquids from other liquids or from solids in solution by boiling at proper temperatures in confinement and condensing the vapor.

2<sup>8</sup> Uses.

1<sup>10</sup> For Separations.

2<sup>10</sup> For Purifications.

4<sup>7</sup> Vapor Pressure.

1<sup>8</sup> Below Freezing Point.

2<sup>8</sup> At Boiling Point.

3<sup>8</sup> At High Temperatures.

5<sup>7</sup> Atmospheric Humidity.

1<sup>8</sup> Definition:—The weight of moisture in a given volume of air.

2<sup>7</sup> Variation:—The amount of moisture in saturated air depends on the temperature.

3<sup>8</sup> Dew Point:—That temperature at which the moisture in any volume of air will saturate it.

4<sup>8</sup> Relative Humidity.

1<sup>9</sup> Definition:—Air is seldom saturate so relative humidity is the ratio

- of contained moisture to the amount of moisture required to saturate a given volume of air.
- 2° Low, Effect of:—That is when the air is dry.
- 3° High, Effect of:—That is when the air is near saturation.
- 4° Psychrometer.
- 5° Heat and Mechanical Energy.
  - 1° Convertibility.
  - 2° Joule's Equivalent:—The heat required to warm a given weight of water one degree F. will lift the water 772 feet or one degree C. will lift it 1,390 feet.
- 3° Sources.
  - 1° Mechanical.
    - 1° Friction.
    - 2° Collision.
    - 3° Compression.
  - 2° Chemical Change.
    - 1° Combustion.
      - 1° Heating Power of Coal.
      - 2° Heating Power of Other Substances.
    - 2° Animal Heat.
    - 3° Plant Temperature.
  - 3° Sun.
  - 4° From Conversion of Electricity.
  - 4° Diffusion of.

1<sup>6</sup> Definition:—The equalizing of temperature of bodies near each other.

2<sup>6</sup> Methods.

1<sup>7</sup> Conduction:—Transference from molecule to molecule through contact.

1<sup>8</sup> Application to Clothing.

2<sup>8</sup> Application to Buildings.

3<sup>8</sup> Application in Solids.

4<sup>8</sup> Application in Liquids.

2<sup>7</sup> Convection:—Distribution by means of currents in liquids and gases.

1<sup>8</sup> Applications to Ventilation.

2<sup>8</sup> Applications to Heating Rooms.

3<sup>7</sup> Radiation:—Transmission of radiate energy through intermolecular ether.

1<sup>8</sup> Radiating Power.

2<sup>8</sup> Radiating in Vacuum.

3<sup>8</sup> Laws.

1<sup>9</sup> Distance:—Heating effect varies inversely as the square of the distance.

2<sup>9</sup> Cooling:—With small difference in temperature the radiation is proportional to the difference in temperature. At high temperatures radiation may equal heat received.

3<sup>6</sup> Isotherms:—Same temperatures.

1<sup>7</sup> Lines:—A line around the earth con-

## TOPICAL OUTLINE OF

necting places with same mean temperature.

2<sup>7</sup> Surfaces.

6<sup>5</sup> Applications Performing Work.

1<sup>6</sup> Steam Engine.

1<sup>7</sup> History.

2<sup>7</sup> Principal Parts.

1<sup>8</sup> Piston.

2<sup>8</sup> Cylinder.

3<sup>8</sup> Eccentric.

4<sup>8</sup> Governor.

5<sup>8</sup> The Injector.

3<sup>7</sup> Kinds.

1<sup>8</sup> Low Pressure.

2<sup>8</sup> High pressure.

2<sup>4</sup> Light.

1<sup>5</sup> Definition:—Radiant energy which when transmitted by ether vibrations so as to impinge upon the retina of the eye is there converted into molecular vibrations which the brain, through the optic nerve, recognizes as light.

2<sup>5</sup> Terms.

1<sup>6</sup> Luminous Bodies:—Those which emit light.

2<sup>6</sup> Transparent Bodies:—Those which absorb little light, transmitting nearly all.

3<sup>6</sup> Translucent Bodies:—Those allowing a little light to pass through them.

- 4<sup>6</sup> Opaque Bodies:—Those which transmit none.
- 5<sup>6</sup> Ray:—A single line of light.
- 6<sup>6</sup> Beam:—Several parallel rays.
- 7<sup>6</sup> Pencil:—Several rays converging to or diverging from a point.
- 3<sup>5</sup> Sources.
  - 1<sup>6</sup> From Incandescent Solid Particles, as in the Sun, Stars, Combustion, etc.
  - 2<sup>6</sup> Electric Spark.
  - 3<sup>6</sup> Phosphoresence.
- 4<sup>5</sup> Propagation:—If unobstructed it passes through the same medium in straight lines.
  - 1<sup>6</sup> Inverted Images by Small Apertures.
  - 2<sup>6</sup> Shadows:—Spaces in which the light from any source is cut off by an opaque body.
    - 1<sup>7</sup> Umbra:—Space in which all the light from any source is cut off.
    - 2<sup>7</sup> Penumbra:—Space in which part of the light from any source is cut off.
- 5<sup>5</sup> Velocity:—186,000 miles per Second.
  - 1<sup>6</sup> Romer's Method.
  - 2<sup>6</sup> Other Methods.
- 6<sup>5</sup> Reflection of Light.
  - 1<sup>6</sup> Definition:—Change of direction in the same medium, caused by striking a polished surface.
  - 2<sup>6</sup> Terms.

- 1<sup>7</sup> Incident Ray:—The ray before reflection.
- 2<sup>7</sup> Reflected Ray:—The ray after reflection.
- 3<sup>7</sup> Normal:—Perpendicular to the reflecting surface at the point of reflection.
- 4<sup>7</sup> Focal Point:—The meeting at one point of several rays which were reflected or started from one point.
- 3<sup>6</sup> Law:—The angles of incidence and reflection are equal.
- 4<sup>6</sup> Examples.
  - 1<sup>7</sup> Heliostat.
  - 2<sup>7</sup> Diffused Light:—Caused by reflection from irregular surfaces.
  - 3<sup>7</sup> By Mirrors.
- 5<sup>6</sup> Images.
  - 1<sup>7</sup> Definition:—A collection of focal points produced by collecting rays from the different points of an object to a set of similarly related points.
  - 2<sup>7</sup> Kinds.
    - 1<sup>8</sup> Virtual or Apparent:—A collection of focal points from which light does not radiate but appears to and is due to the rays being reflected diverging.
    - 2<sup>8</sup> Real:—A collection of focal points from which light really radiates.

6<sup>6</sup> Mirrors.

1<sup>7</sup> Definition:—Highly polished surfaces which reflect nearly all the light falling upon them.

2<sup>7</sup> Kinds.

1<sup>8</sup> Plane:—Plane, polished, reflecting surfaces.

1<sup>9</sup> Reflection by.

2<sup>9</sup> Images by.

3<sup>9</sup> Reversion of Images.

2<sup>8</sup> Curved:—Segments of the surface of spheres and highly polished.

1<sup>9</sup> Terms.

1<sup>10</sup> Center of Curvature:—Center of the sphere of which the mirror is a segment.

2<sup>10</sup> Principal Axis:—A line through the center of the mirror and the center of curvature.

3<sup>10</sup> Secondary Axis:—A line through the center of curvature and any point of the mirror outside the center.

4<sup>10</sup> Principal Focus:—Point where parallel rays are focused by curved mirrors.

5<sup>10</sup> Conjugate Foci:—Any two points on the principal axis such that a luminous point be placed at

either, its rays will be focused at the other.

6<sup>10</sup> Perpendicular:—All radii of a sphere are perpendicular to its surface.

2<sup>9</sup> Kinds.

1<sup>10</sup> Concave:—One whose surface is a part of the inside of the surface of a sphere.

1<sup>11</sup> Images by.

1<sup>12</sup> Object between the Mirror and its Principal Focus.

2<sup>12</sup> Object between the Principal Focus and its Center.

3<sup>12</sup> Object beyond the Center.

2<sup>11</sup> Examples.

2<sup>10</sup> Convex:—One whose surface is part of the outside of a sphere.

1<sup>11</sup> Images by.

2<sup>11</sup> Examples.

7<sup>5</sup> Refraction of Light.

1<sup>6</sup> Definition:—Change of direction of rays as they pass from one medium to another of different density.

2<sup>6</sup> Law:—The quotients of the sine of the angle of incidence by the sine of the angle of refraction are always equal for the same media.

1<sup>7</sup> Entering the New Medium Perpendic-

- ular to the Surface:—No refraction.
- 2<sup>7</sup> Entering a Denser Medium Oblique to the Surface:—Bends toward a perpendicular to the surface.
- 3<sup>7</sup> Entering a Rarer Medium Oblique to the Surface:—Bends from the perpendicular.
- 3<sup>6</sup> Index:—The constant ratio between the sines.
- 4<sup>6</sup> Phenomena of.
  - 1<sup>7</sup> Sticks Partly Immersed.
  - 2<sup>7</sup> Sticks Wholly Immersed.
  - 3<sup>7</sup> Apparent Depth of Water.
  - 4<sup>7</sup> Atmospheric Refraction.
    - 1<sup>8</sup> Effects Upon Heavenly Bodies.
    - 2<sup>8</sup> Mirage.
- 5<sup>6</sup> Total Reflection:—When a ray reaches surface of rarer medium if the angle of incidence is so large as to give the sine of the angle of refraction greater than unity, the ray cannot pass out and will obey the law of reflection, being more perfect than any external reflection.
  - 1<sup>7</sup> Critical Angle:—The angle of incidence which will give an angle of refraction in the rarer medium of unity.
  - 2<sup>7</sup> Examples.

1<sup>s</sup> In Prisms.

2<sup>s</sup> Camera Lucida.

6<sup>s</sup> Cause:—It is due to the velocity of light being greater in the less refracting medium.

7<sup>s</sup> Lenses and Prisms.

1<sup>7</sup> Definition:—(a) Masses of transparent matter having two surfaces, one or both of which are the surfaces of spherical segments. (b) A refracting mass bounded by planes inclined at any angle.

2<sup>7</sup> Terms.

1<sup>s</sup> Center of Curvature:—Center of the sphere of which the spherical surface is a part.

2<sup>s</sup> Normal:—Radius of the sphere of which the surface is a part.

3<sup>s</sup> Optical Center:—A point on the principal axis equally distant from the two faces of a lens whose surfaces have equal radii.

3<sup>7</sup> Kinds.

1<sup>s</sup> Double Convex:—Both surfaces convex.

2<sup>s</sup> Plano-Convex:—One surface convex, one plane.

3<sup>s</sup> Concavo-Convex:—The convex surface being a segment of a smaller

sphere than the concave one.  
(Meniscus.)

4<sup>8</sup> Double Concave:—Both surfaces concave.

5<sup>8</sup> Plano-Concave:—One surface concave, one plane.

6<sup>8</sup> Convexo-Concave:—Concave surface being a segment of a smaller sphere than the convex.

4<sup>7</sup> Foci.

1<sup>8</sup> In Converging Lenses.

1<sup>9</sup> Principal:—Point to where the parallel rays are collected after passing through the lens.

2<sup>9</sup> Conjugate:—Luminous points beyond the principal focus but not infinitely removed will give real, interchangeable foci.

3<sup>9</sup> Virtual:—Luminous points nearer the lens than the principal focus will give divergent rays after refraction and the foci are only apparent.

2<sup>8</sup> In Divergent Lenses.

1<sup>9</sup> Principal Focus:—Parallel rays are divergent after refraction and the virtual focus from which they seem to come is the principal.

2<sup>9</sup> Conjugate Foci:—There are none.

- 5<sup>7</sup> Images by.
  - 1<sup>8</sup> Convex.
    - 1<sup>9</sup> Object at the Principal Focus.
    - 2<sup>9</sup> Object Nearer than Principal Focus.
    - 3<sup>9</sup> Object Beyond the Principal Focus.
  - 2<sup>8</sup> Concave.
    - 1<sup>9</sup> Images by.
    - 2<sup>9</sup> Examples.
- 6<sup>7</sup> Spherical Aberration.
  - 1<sup>8</sup> Definition:—Distortion of image by the lens refracting more at the margins than the center.
  - 2<sup>8</sup> Correction.
    - 1<sup>9</sup> By Shape of Lens.
    - 2<sup>9</sup> By Combination of Lenses.
    - 3<sup>9</sup> By Diaphragms.
- 7<sup>7</sup> Chromatics:—That subject which treats of color.
  - 1<sup>8</sup> Color:—The sensations produced upon the optic nerve by light vibrations of different wave lengths.
  - 2<sup>8</sup> Dispersion:—Lenses and prisms refract rays of shortest wave length and hence most rapid vibration most, hence the different rays are separated.
  - 3<sup>8</sup> Chromatic Aberration.
    - 1<sup>9</sup> Definition:—Rings of color around

the margin of the field viewed by a lens, due to its dispersive power.

2<sup>9</sup> Correction:—By combinations.

4<sup>8</sup> Prismatic Spectrum:—A prism decomposes white light into seven colors.

5<sup>8</sup> Mixing colors.

1<sup>9</sup> By Reflection.

2<sup>9</sup> By Newton's Disk.

6<sup>8</sup> Complementary Colors : — Colors which combined produce white light.

7<sup>8</sup> Color of Bodies:—The color of the ray which a body reflects determines its color, the rest being converted into heat waves and thus quenched.

8<sup>8</sup> Color Sense and Blindness.

9<sup>8</sup> Color fatigue.

10<sup>8</sup> Mutual Effect of Colors.

11<sup>8</sup> Spectrum Analysis.

1<sup>9</sup> Spectroscope.

2<sup>9</sup> Solar Spectrum.

1<sup>10</sup> Parts.

1<sup>11</sup> Luminous:—It includes all the colored portion but is most intense in the orange.

2<sup>11</sup> Thermal : — That producing heat, greatest in the red and beyond it.

- 3<sup>11</sup> Actinic :— That part where the rays provoke chemical changes, is greatest in the violet and beyond it.
- 2<sup>10</sup> Fraunhofer's Lines.
- 3<sup>9</sup> Other Spectra.
- 4<sup>9</sup> Applications.
- 12<sup>8</sup> Rainbow.
- 1<sup>9</sup> Explanation.
- 2<sup>9</sup> Classes.
  - 1<sup>10</sup> Primary.
  - 2<sup>10</sup> Secondary.
  - 3<sup>9</sup> Why Semicircular.
- 8<sup>7</sup> Intensity of Illumination:—Inversely as the square of the distance from the source of illumination.
- 8<sup>6</sup> Camera Obscura.
- 9<sup>6</sup> Vision.
  - 1<sup>7</sup> Definition:—The perception of objects through their illumination, by the light which is reflected from them into the eye.
  - 2<sup>7</sup> Description of the Structure of the Eye.
  - 3<sup>7</sup> Accommodation:—Accomplished by a change in the curvature of the crystalline lens.
  - 4<sup>7</sup> Single Vision:—By converging the axes of the two eyes on the same point, the images are made upon the same parts of the retinas.

- 5<sup>7</sup> Estimation of Magnitude and Distance.
- 6<sup>7</sup> Why We See Objects Erect.
- 7<sup>7</sup> Visual Angle:—Angle bounded by lines drawn from the extremities of an object to the eye.
- 8<sup>7</sup> Optical Imperfections of the Eye.
  - 1<sup>8</sup> Astigmatism:—Inability to focus light from horizontal and vertical lines at the same time.
  - 2<sup>8</sup> Long and Short Sight.
  - 3<sup>8</sup> Irradiation:—The enlarged appearance of luminous objects.
  - 4<sup>8</sup> Chromatic Aberration.
- 9<sup>7</sup> Blind Spot.
- 10<sup>7</sup> Care of the Eye.
- 11<sup>7</sup> Phenomena of Interference.
  - 1<sup>8</sup> Newton's Rings.
  - 2<sup>8</sup> Diffraction:—The bending of luminous rays at the edge of an opaque body or beyond a narrow slit into the shadow.
- 8<sup>6</sup> Polarization.
  - 1<sup>6</sup> Definition:—The changing of a ray so that the vibrations are quenched in some planes.
  - 2<sup>6</sup> Kinds.
    - 1<sup>7</sup> Plane:—When vibrations exist only in one plane.
    - 2<sup>7</sup> Circular:—When vibrations still exist in more than one plane.

- 3<sup>5</sup> Methods.
  - 1<sup>7</sup> By Reflection.
  - 2<sup>7</sup> By Double Refraction.
    - 1<sup>8</sup> By Calcite.
    - 2<sup>8</sup> By Nicol's Prism.
  - 4<sup>5</sup> Polariscopes.
  - 5<sup>5</sup> Tourmaline Tongs.
  - 6<sup>5</sup> Applications.
- 9<sup>5</sup> Optical Instruments.
  - 1<sup>6</sup> Microscopes.
    - 1<sup>7</sup> Simple.
      - 1<sup>8</sup> Construction.
      - 2<sup>8</sup> Characteristics.
    - 2<sup>7</sup> Compound.
      - 1<sup>8</sup> Construction.
      - 2<sup>8</sup> Characteristics.
  - 2<sup>6</sup> Telescopes.
    - 1<sup>7</sup> Refracting.
      - 1<sup>8</sup> Galilean.
      - 2<sup>8</sup> Opera Glass.
      - 3<sup>8</sup> Astronomical.
      - 4<sup>8</sup> Terrestrial.
    - 2<sup>7</sup> Reflecting.
  - 3<sup>5</sup> Stereopticon.
  - 4<sup>5</sup> Stereoscope.
- 10<sup>5</sup> Photometry: — Measures of illuminating power.
- 3<sup>4</sup> Acoustics.
  - 1<sup>5</sup> Definition:—That branch of physics which

treats of the origin, nature and transmission of the vibrations causing sound, and of the mechanism of acoustic instruments.

2<sup>5</sup> Sound:—The sensation peculiar to the ear, caused by vibrations transmitted to the nerves of hearing.

3<sup>5</sup> Mechanism of Hearing.

4<sup>5</sup> Origin of Vibrations:—The vibration of some solid, liquid, or gaseous body.

5<sup>5</sup> Transmission of Vibrations.

1<sup>6</sup> Through Air.

2<sup>6</sup> Through other Media.

3<sup>6</sup> Through a Vacuum.

4<sup>6</sup> Velocity.

1<sup>7</sup> In Air:—1,090 ft. per second, temperature 32° F.

1<sup>8</sup> Variations.

1<sup>9</sup> By Temperature:—1 ft. increase for 1° F. rise.

2<sup>9</sup> By Density:—Inversely as the square roots of the densities.

3<sup>9</sup> By Elasticity.

2<sup>8</sup> Ordinary.

2<sup>7</sup> In Other Media.

3<sup>7</sup> For High and Low Notes.

4<sup>7</sup> How Determined?

5<sup>6</sup> Principle of.

1<sup>7</sup> Illustrate by Elastic Balls.

- 2<sup>7</sup> Compression and Expansion in Tubes.
- 3<sup>7</sup> Nature of Sound Waves.
  - 1<sup>8</sup> Rarefactions.
  - 2<sup>8</sup> Condensations.
  - 3<sup>8</sup> Wave Lengths:—Distance from any particle to the next particle in like phase.
  - 4<sup>8</sup> Wave Period:—Time required for a complete vibration of a particle.
  - 5<sup>8</sup> Amplitude:—Distance through which the particles vibrate.
  - 6<sup>8</sup> Crova's Disk.
- 6<sup>5</sup> Phenomena of Sound.
  - 1<sup>6</sup> Reflection:—Same as light and heat.
  - 1<sup>7</sup> Law:—Same as light.
  - 2<sup>7</sup> Examples.
    - 1<sup>8</sup> Echo:—Repetition of sound by reflections from obstructions.
    - 1<sup>9</sup> Single:—One repetition.
    - 2<sup>9</sup> Multiple:—Several repetitions.
    - 3<sup>9</sup> Distance of Reflecting Surface:—112 ft. for one short syllable, etc.
  - 2<sup>8</sup> Whispering Galleries.
  - 3<sup>8</sup> Ear Trumpets.
  - 4<sup>8</sup> Audiphones.
  - 5<sup>8</sup> Speaking Trumpets.
  - 6<sup>8</sup> Resonance:—The reinforcement of sound by reflecting waves being superimposed on those the last part of the impulse.

- 7<sup>s</sup> Speaking Tubes.
- 2<sup>6</sup> Modifications of Sound.
  - 1<sup>7</sup> Intensity.
    - 1<sup>8</sup> By Amplitude of Vibration.
    - 2<sup>8</sup> By Distance.
    - 3<sup>8</sup> By Change of Media.
  - 2<sup>7</sup> Interference.
  - 3<sup>6</sup> Refraction:—Same as light.
  - 4<sup>6</sup> Diffraction:—Same as light.
  - 5<sup>6</sup> Vibrations of Sounding Bodies.
    - 1<sup>7</sup> Strings.
      - 1<sup>8</sup> Sonometer.
      - 2<sup>8</sup> Laws.
        - 1<sup>9</sup> Of Length:—Tension constant, the number vibrations in the same time will vary inversely as the length of the string.
        - 2<sup>9</sup> Diameter:—Constant tension, same substance and length, the number of vibrations in the same time will vary inversely as the diameters.
        - 3<sup>9</sup> Tension:—Length and diameter the same, the number of vibrations will vary as the square root of stretching force.
    - 2<sup>8</sup> Vibrations as Whole:—Gives fundamental tones.
    - 4<sup>8</sup> Vibrations as Parts:—Gives overtones.

- 2<sup>7</sup> Air in Tubes:—As organ pipes, etc.
- 3<sup>7</sup> Rods.
- 4<sup>7</sup> Plates.
  - 1<sup>8</sup> Chladni's Figures.
  - 2<sup>8</sup> Vibrations of a Bell.
- 5<sup>7</sup> Sympathetic Vibrations.
- 6<sup>7</sup> Counting Vibrations:—By the Sirene.
- 6<sup>6</sup> Noise:—Vibrations so slow as not to appear continuous or at irregular intervals.
- 7<sup>7</sup> Musical Sounds.
  - 1<sup>7</sup> Definition:—Vibrations at regular intervals and so frequent as to appear continuous.
  - 2<sup>7</sup> Illustrations.
  - 3<sup>7</sup> Elements.
    - 1<sup>8</sup> Loudness:—Varied by varying the amplitude of vibration.
    - 2<sup>8</sup> Pitch:—Depends upon the number of vibrations per second of time.
    - 3<sup>8</sup> Timbre:—The quality, and depends upon the overtones cording with the fundamental.
    - 4<sup>9</sup> Fundamental Tone:—The note produced by the body vibrating as a whole.
    - 2<sup>9</sup> Harmonics:—When the vibrations of the segments of a body chord with the fundamental tone we

have harmony and good quality.

3<sup>9</sup> Overtones:--When the overtones do not chord with the fundamental we have bad quality.

4<sup>9</sup> Analysis of Complex Sounds.

1<sup>10</sup> Co-Vibration.

2<sup>10</sup> Helmholtz. Resonantors.

8<sup>6</sup> Musical Scale.

1<sup>7</sup> Definition:--A series of tones differing in pitch by definite ratios of vibrations.

2<sup>7</sup> Kinds.

1<sup>8</sup> Natural Scale.

2<sup>8</sup> Equal Temperament Scale.

3<sup>7</sup> Octave:--Note having twice the number of vibrations of the first note in the scale.

9<sup>6</sup> Beats:--When interference of vibrations gives perceptible impulses they are called beats.

10<sup>6</sup> Musical Instruments.

1<sup>7</sup> Stringed.

2<sup>7</sup> Wind.

1<sup>8</sup> Reed.

2<sup>8</sup> Pipes.

3<sup>7</sup> How tuned.

11<sup>6</sup> Voice.

1<sup>7</sup> Vocal Organs.

2<sup>7</sup> Disorders of.

- 3<sup>7</sup> Speech.
- 12<sup>6</sup> Phonograph.
- 4<sup>4</sup> Magnetism.
  - 1<sup>5</sup> Definition:—That branch of physics which treats of magnets, their properties, and the laws of their action.
  - 2<sup>5</sup> Magnets.
    - 1<sup>6</sup> Definition:—Masses of iron, iron ore, or steel, which are capable of attracting iron, steel, nickel, cobalt, and a few such substances.
  - 2<sup>6</sup> Kinds.
    - 1<sup>7</sup> Natural:—Generally of Magnetite  $\text{Fe}_3 \text{O}_4$  and found in nature, (Lodestone)
    - 2<sup>7</sup> Artificial:—Those to which magnetism has been imparted by some known process.
  - 1<sup>8</sup> Varieties.
    - 1<sup>9</sup> As to Production.
      - 1<sup>10</sup> Temporary:—Usually of soft iron, and are only magnetized while under the effect of contact or induction of another magnet, or in proper relation to an electric current.
      - 2<sup>10</sup> Permanent:—Made of steel and when magnetized remain in that condition.

- 2<sup>9</sup> As to Form.
  - 1<sup>10</sup> Bar-Magnets.
  - 2<sup>10</sup> Horse Shoe Magnets.
  - 3<sup>10</sup> Magnetic Needles.
  - 4<sup>10</sup> Compound.
    - 1<sup>11</sup> Description.
    - 2<sup>11</sup> Why Preferable.
- 3<sup>6</sup> Properties.
  - 1<sup>7</sup> Attraction.
    - 1<sup>8</sup> Through Bodies.
    - 2<sup>8</sup> In Vacuum.
    - 3<sup>8</sup> Polarity:—A name for the attractive power being greatest at the ends.
      - 1<sup>9</sup> North Pole.
      - 2<sup>9</sup> South Pole.
      - 3<sup>9</sup> Neutral Line:—Line at the middle where there is no attractive force.
  - 4<sup>8</sup> Law.
    - 1<sup>9</sup> First:—Like poles repel, unlike attract.
      - 1<sup>10</sup> Illustrations.
      - 2<sup>10</sup> Neutralizing Effect:— Opposite poles.
      - 3<sup>10</sup> Astatic Needle.
    - 2<sup>9</sup> Second:—The force between poles is proportional to the product of their strength and inversely proportional to the square of the distance between them. .

- 2<sup>7</sup> Poles Inseparable.
  - 1<sup>8</sup> Effect of Breaking.
  - 2<sup>8</sup> Reason Why.
- 3<sup>7</sup> Induction.
  - 1<sup>8</sup> Definition:—Magnetizing by bringing iron near enough to a magnet to be within the field of its magnetic force.
  - 2<sup>8</sup> Bar Armature.
  - 3<sup>8</sup> Wheel Armature.
  - 4<sup>8</sup> Magnetic Chain.
- 4<sup>7</sup> Retentivity:—The power of retaining magnetism.
- 5<sup>7</sup> Lifting Power.
- 4<sup>6</sup> Magnetization.
  - 1<sup>7</sup> By Single Touch.
  - 2<sup>7</sup> By Double Touch.
- 5<sup>6</sup> Preservation of.
- 6<sup>6</sup> Lines of Force and Magnetic Field.
- 7<sup>6</sup> Earth's Magnetism.
  - 1<sup>7</sup> Magnetic Poles:—These do not coincide with geographic poles. Some observers think there are four, two north and two south. They are about 20° away from the poles.
  - 2<sup>7</sup> Magnetic Equator:—It forms an irregular curve inclined to the geographical equator, generally about 12,° but having nodes so it

crosses the true equator in four places.

3<sup>7</sup> Magnetic Needle.

1<sup>8</sup> Definition:—A magnetized needle or pointed bar which is freely suspended and in response to the directive tendency of the earth places itself in a north and south direction.

2<sup>8</sup> Declination.

1<sup>9</sup> Definition:—The angle the needle makes with the true geographical meridian.

2<sup>9</sup> Variation:—Changes in declination.

1<sup>10</sup> Secular:—A slow change vibrating in character and requiring about 320 years to pass from one extreme to the other.

2<sup>10</sup> Annual:—A yearly oscillation of about 15° or 16°, related to the frequency of recurrence of aurora borealis and sun spots.

3<sup>10</sup> Daily:—An oscillation of from 5' to 12' and occurring daily.

4<sup>10</sup> Isogonic Curves:—Lines drawn through points of equal declination.

5<sup>10</sup> Agones:—Lines of no variation, there are three in all.

- 3<sup>s</sup> Dip:—The needle if suspended and free to move in a vertical plane will be horizontal on the magnetic equator. North of it the north end is depressed and at the magnetic pole it stands vertical. South of it the reverse is true.
- 4<sup>t</sup> Magnetic Meridians:—Lines described by transporting a declination needle so that it constantly moves in the direction in which it is pointing.
- 5<sup>t</sup> Isoclinic Curves:—Magnetic parallels, connecting points of equal declination.
- 8<sup>6</sup> Applications of Magnetism.
  - 1<sup>7</sup> □ Mariner's Compass.
    - 1<sup>s</sup> Description.
    - 2<sup>s</sup> History.
    - 3<sup>s</sup> Correction for Declination.
  - 2<sup>7</sup> Separation of Ores.
  - 3<sup>7</sup> By Surgeons.
  - 4<sup>7</sup> As Electrical Generators.
- 5<sup>4</sup> Electricity.
  - 1<sup>5</sup> Definition:—That form of Energy which manifests itself in mutual attractions and repulsions between like Bodies and is readily converted into other forms of energy.
  - 2<sup>5</sup> Compared with Heat.

- 3<sup>5</sup> Potential:—The difference between bodies which produces electrical phenomena between them.
- 4<sup>5</sup> Properties of Electrified bodies.
  - 1<sup>6</sup> Attractions and Repulsions.
  - 2<sup>6</sup> Terms.
    - 1<sup>7</sup> Conductors:—Substances which offer little resistance to the passage of electricity.
    - 2<sup>7</sup> Insulators:—Those bodies which offer a high resistance to the passage of electricity.
  - 3<sup>6</sup> Kinds.
    - 1<sup>7</sup> Positive:—That electrical charge developed upon glass when rubbed with silk.
    - 2<sup>7</sup> Negative:—That electricity developed on gutta serena when rubbed with silk.
    - 3<sup>7</sup> Potential Series:—A list of substances named in such order that if any two of them be rubbed together, the first in the list will become positively charged and the other negative.
- 5<sup>5</sup> Theory of.
  - 1<sup>6</sup> First:—That neutral bodies contain equal and equally distributed quantities of positive and negative electricities.
  - 2<sup>6</sup> Second:—That we may assume these electricities to be unlimited in amount.

- 3<sup>o</sup> Third:—That to electrify a body we must produce electrical separation and by removal or addition make one kind exceed the other.
- 6<sup>o</sup> Laws of Electrical Attraction and Repulsion.
  - 1<sup>o</sup> First:—Like signs repel, unlike attract.
  - 2<sup>o</sup> Second:—The force exerted between two charges is proportional to the products of their quantities and inversely proportional to the square of the distance between them.
  - 3<sup>o</sup> Unit Quantity:—The quantity that will attract an equal quantity of unlike sign at a distance of one cm. with a force of one dyne.
- 7<sup>o</sup> Forms.
  - 1<sup>o</sup> Statical:—That form produced by friction.
    - 1<sup>o</sup> Characteristics.
      - 1<sup>o</sup> High potential.
      - 2<sup>o</sup> Sudden and Violent Effects.
    - 2<sup>o</sup> Methods of Electrification.
      - 1<sup>o</sup> By Friction.
      - 2<sup>o</sup> By Contact.
      - 3<sup>o</sup> By Induction.
      - 4<sup>o</sup> Why is Insulation Sometimes Necessary.
    - 5<sup>o</sup> Electricity Confined to Surface of Conducting Shells.

- 1<sup>9</sup> Gauze Cylinders.
- 2<sup>9</sup> Faraday's Bag.
- 6<sup>8</sup> Density Greatest at Points.
  - 1<sup>9</sup> Oval Brass Shell.
  - 2<sup>9</sup> Brush:—Luminosity of points.
  - 3<sup>9</sup> St. Elmo's Fire.
  - 4<sup>9</sup> Electric Whirl.
- 7<sup>8</sup> Apparatus.
  - 1<sup>9</sup> Electrophorus.
  - 2<sup>9</sup> Machines.
    - 1<sup>10</sup> Induction.
    - 2<sup>10</sup> Thomson's Water Dropping.
    - 3<sup>10</sup> Toepler Holtz.
    - 4<sup>10</sup> Friction.
    - 5<sup>10</sup> Di-Electric.
  - 3<sup>9</sup> Condensers: — Electrical accumulators.
    - 1<sup>10</sup> Leyden Jar.
      - 1<sup>11</sup> History.
      - 2<sup>11</sup> Action.
        - 1<sup>12</sup> Charging.
        - 2<sup>12</sup> Discharging.
        - 3<sup>12</sup> Residual Discharge.
      - 3<sup>11</sup> Dischargers.
    - 2<sup>10</sup> Leyden Battery.
    - 3<sup>10</sup> Electrified Ball Inside Conducting Shell.
      - 1<sup>11</sup> Charging.
      - 2<sup>11</sup> Screening Effect of Metallic Shell.

- 3<sup>10</sup> Cause of Increased Capacity.
- 3<sup>7</sup> Effects.
  - 1<sup>8</sup> Mechanical.
    - 1<sup>9</sup> Attraction and Repulsion.
      - 1<sup>10</sup> Electric Chime.
      - 2<sup>10</sup> Dancing Images.
    - 2<sup>9</sup> Rupture of Substances.
      - 1<sup>10</sup> Piercing Cards.
      - 2<sup>10</sup> Piercing Glass.
  - 2<sup>8</sup> Thermal (Heating).
    - 1<sup>9</sup> Igniting Substances.
      - 1<sup>10</sup> Alcohol.
      - 2<sup>10</sup> Gunpowder.
      - 3<sup>10</sup> Ether.
    - 2<sup>9</sup> Heating Substances.
      - 1<sup>10</sup> Incandescence of Wire.
      - 2<sup>10</sup> Fusing Wire.
- 3<sup>8</sup> Chemical.
  - 1<sup>9</sup> Exploding Gases.
  - 2<sup>9</sup> Electrolysis.
- 4<sup>8</sup> Luminous.
  - 1<sup>9</sup> Spark in Air.
    - 1<sup>10</sup> Course.
    - 2<sup>10</sup> Color.
    - 3<sup>10</sup> Duration.
  - 2<sup>9</sup> Luminous Surfaces.
    - 1<sup>10</sup> Luminous Pane.
    - 2<sup>10</sup> Luminous Tube.
  - 3<sup>9</sup> Spark in Rarefied Gases.

- 1<sup>10</sup> Luminous Vases.
- 2<sup>10</sup> Geisler Tubes.
- 5<sup>8</sup> Physiological.
  - 1<sup>9</sup> Shock.
  - 2<sup>9</sup> Charged Person.
- 6<sup>8</sup> Lightning.
  - 1<sup>9</sup> Source of Cloud Electricity.
  - 2<sup>9</sup> Protection from Lightning.
    - 1<sup>10</sup> By Metal Strips.
    - 2<sup>10</sup> By Lightning Rods.
      - 1<sup>11</sup> How Rods Protect.
      - 2<sup>11</sup> Construction.
- 7<sup>8</sup> Aurora Borealis.
- 8<sup>8</sup> Magnetic.
  - 1<sup>9</sup> Discharge through a Coil of Insulated Wire Wound around a Glass Tube Containing a Soft Iron Core.
  - 2<sup>9</sup> Discharge through a Coil around a Suspended Magnetic Needle.
  - 3<sup>9</sup> Galvanometer.
- 9<sup>8</sup> Produce Currents through Conductors.
- 2<sup>6</sup> Current Electricity.
  - 1<sup>7</sup> Voltaic.
    - 1<sup>8</sup> History.
    - 2<sup>8</sup> Production.
      - 1<sup>9</sup> Voltaic Cells.
        - 1<sup>10</sup> Construction.
        - 2<sup>10</sup> Action.

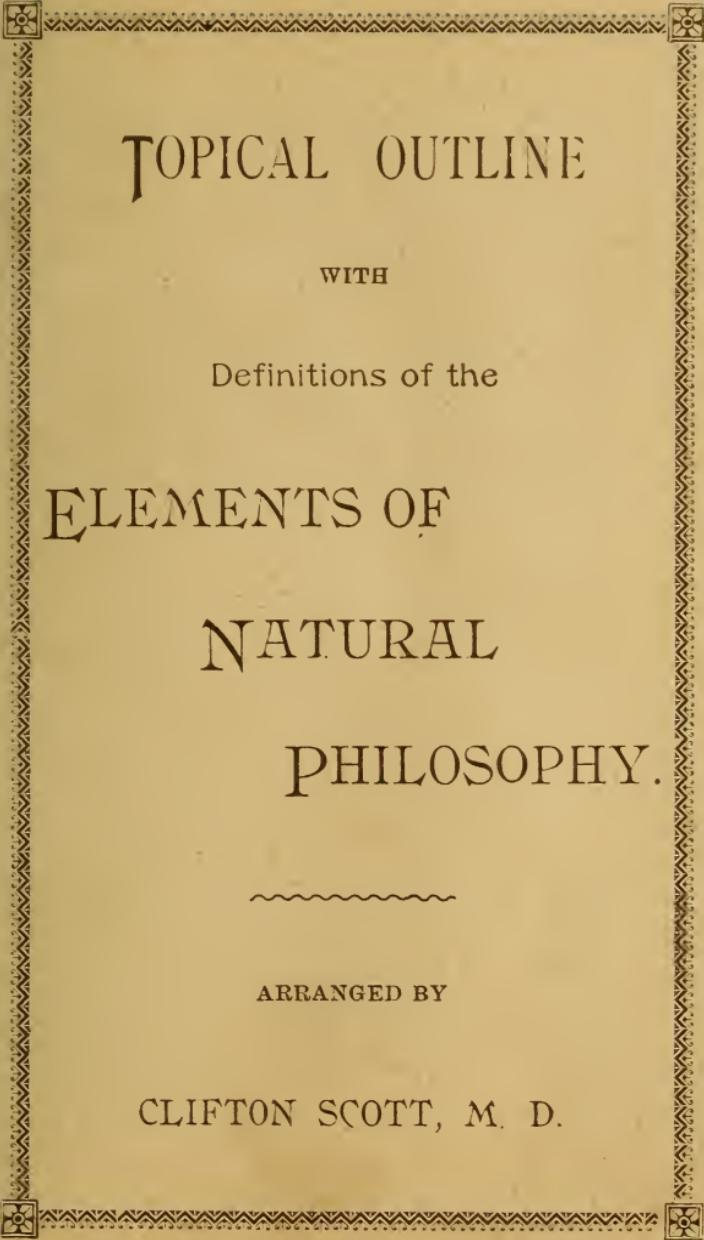
- 3<sup>10</sup> Plates.
- 4<sup>10</sup> Electrodes.
- 5<sup>10</sup> Properties.
- 6<sup>10</sup> Amalgamation of Plates.
- 7<sup>10</sup> Polarization.
- 8<sup>10</sup> Kinds.
  - 1<sup>11</sup> Gravity.
  - 2<sup>11</sup> Grove.
  - 3<sup>11</sup> Bunsen.
  - 4<sup>11</sup> Leclanche.
  - 5<sup>11</sup> Bichromate.
- 2<sup>9</sup> Voltaic Battery.
  - 1<sup>10</sup> Construction.
  - 2<sup>10</sup> Arrangement of Cells.
    - 1<sup>11</sup> In Series, Tandem, High Internal Resistance.
    - 2<sup>11</sup> In Multiple Arc, Parallel, Low Internal Resistance.
    - 3<sup>11</sup> Proper Arrangement.
- 8<sup>5</sup> Electrical Measurements.
  - 1<sup>6</sup> Importance of.
  - 2<sup>6</sup> Measurement of Resistance.
    - 1<sup>7</sup> Unit of Resistance:—Ohm.
    - 2<sup>7</sup> Laws of Resistance.
      - 1<sup>8</sup> First:—Resistance varies as the length of the conductor.
      - 2<sup>8</sup> Second:—Resistance varies inversely as the square of the diameter of the conductor.

- 3<sup>8</sup> Third:—Resistance depends upon the material of the conductor.
- 3<sup>7</sup> Apparatus.
  - 1<sup>8</sup> Resistance Coils.
  - 2<sup>8</sup> Resistance Coils in Box.
  - 3<sup>8</sup> Standard Coils.
  - 4<sup>8</sup> Differential Galvanometer.
- 4<sup>7</sup> By Coils.
- 5<sup>7</sup> By Galvanometer.
- 6<sup>7</sup> Why Necessary.
  - 1<sup>8</sup> As a Guide in Battery Arrangement.
  - 2<sup>8</sup> To Discover Faults and Breaks.
- 7<sup>7</sup> Caution in Measuring.
- 3<sup>6</sup> Measurement of Current.
  - 1<sup>7</sup> Unit of Current:—Ampere.
  - 2<sup>7</sup> By Electrolysis.
    - 1<sup>8</sup> Terms.
      - 1<sup>9</sup> Anodes.
      - 2<sup>9</sup> Cathodes.
    - 2<sup>8</sup> Current of Polarization.
  - 3<sup>7</sup> By Magnetic Action.
    - 1<sup>8</sup> Ampere's Rule.
    - 2<sup>8</sup> Ampere Meter.
    - 3<sup>8</sup> Tangent Galvanometer.
      - 1<sup>9</sup> Description.
      - 2<sup>9</sup> Law:—The strength of the current is proportional to the tangent of the angle of deflection.
- 4<sup>7</sup> Current Depends on E. M. F. of Battery and Resistance of Circuit.

- 4<sup>6</sup> Measurements of Electro Motive Force.
  - 1<sup>7</sup> Definition of E. M. F.:—The power of driving electricity through the resistance of a circuit.
  - 2<sup>7</sup> Circuits:—The continuous conductors through which a current travels.
    - 1<sup>8</sup> External Resistance.
    - 2<sup>8</sup> Internal Resistance.
  - 3<sup>7</sup> Unit of E. M. F.:—The Volt, it is the electrical pressure required to maintain a current of one Ampere through a resistance of one Ohm.
  - 4<sup>7</sup> By Electrometers.
    - 1<sup>8</sup> Quadrant.
    - 2<sup>8</sup> Volt Meter.
  - 5<sup>7</sup> Ohm's Law.  $C = \frac{E}{R}$
  - 6<sup>7</sup> E. M. F.:—Depends upon the material of the cell.
- 5<sup>5</sup> Dividing Circuits and Shunts.
  - 1<sup>7</sup> Law:—The current in the branches is inversely as their resistance.
  - 2<sup>7</sup> Short Circuits.
  - 3<sup>7</sup> Shunted Galvanometers.
- 6<sup>6</sup> Heating by Currents.
  - 1<sup>7</sup> Calorimeter.
  - 2<sup>7</sup> Heat Waste in Wires:
- 9<sup>5</sup> Applications of Electricity.
  - 1<sup>6</sup> Value of.

- 3<sup>6</sup> Electro Magnet.
  - 1<sup>7</sup> History.
  - 2<sup>7</sup> Properties.
  - 3<sup>7</sup> Construction.
  - 4<sup>7</sup> Application.
  - 1<sup>8</sup> Electro Magnetic Telegraph.
    - 1<sup>9</sup> History.
    - 2<sup>9</sup> Action.
    - 3<sup>9</sup> Key.
    - 4<sup>9</sup> Sounder.
    - 5<sup>9</sup> Register.
    - 6<sup>9</sup> Code of Signals.
    - 7<sup>9</sup> Relay.
    - 8<sup>9</sup> Duplex.
  - 2<sup>8</sup> Electric Bells.
  - 3<sup>8</sup> Electric Clocks.
- 3<sup>6</sup> Electro Magnetic Induction.
  - 1<sup>7</sup> By Magnets in Coils.
  - 2<sup>7</sup> Induction Coil.
    - 1<sup>8</sup> Core.
    - 2<sup>8</sup> Primary Coil.
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    - 4<sup>8</sup> Action.
    - 5<sup>8</sup> Spark.
    - 6<sup>8</sup> E. M. F.
    - 7<sup>8</sup> Ruhmkorff.
    - 8<sup>8</sup> Applications.
  - 1<sup>9</sup> Telephone.
  - 1<sup>10</sup> Receiver.

- 2<sup>10</sup> Transmitter.
- 2<sup>9</sup> Microphone.
- 3<sup>9</sup> Dynamo Electric Machine.
  - 1<sup>10</sup> Magnets.
  - 2<sup>10</sup> Armature.
    - 1<sup>11</sup> Gramme Ring.
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  - 3<sup>10</sup> Commutator.
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    - 2<sup>8</sup> Electro-Typing.
  - 3<sup>7</sup> Storage Batteries.
  - 5<sup>6</sup> Electricity in Warfare.
  - 7<sup>6</sup> Electricity in Medicine.



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